Clinical performance of chairside CAD/CAM restorations

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The application of computer-aided design/computer-aided manufacturing (CAD/CAM) technology in dentistry is having a profound effect on both dental laboratories and clinics. The CEREC system (Sirona Dental Systems GmbH, Bensheim, Germany) is a chairside application of CAD/CAM technology for restorative dentistry that is marking its 20th year of clinical service.

The CEREC 1 unit was developed to fabricate inlays and onlays chairside for immediate cementation; thus, the majority of published long-term clinical studies on CEREC-generated restorations focus on inlays and onlays. Continual development of the hardware and software has expanded the restorative capabilities significantly. The current CEREC 3 system can fabricate inlays, onlays and posterior crowns, as well as

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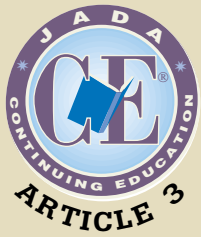
ABSTRACT



Background. The CEREC system (Sirona Dental Systems GmbH, Bensheim, Germany) is marking its 20th year of clinical service. The author reviews the literature on the effectiveness of this chairside CAD/CAM system.

Types of Studies Reviewed. The author identified and reviewed clinical studies from 1985 through 2006 that included CEREC-generated inlays, onlays or crowns. These studies were conducted in both private practice and university settings. The author summarized the findings as they relate to postoperative sensitivity, restoration fracture, color match, margin adaptation and clinical longevity.

Results. Although postoperative sensitivity was reported, it was due to mainly occlusal interferences. Long-term postoperative sensitivity was not a reported problem. Similar to other ceramic restorations, restoration fracture is the primary mode of failure for CEREC-generated restorations. Although margin wear is detected consistently, consequences of the wear leading to restoration failure were reported rarely. The survival probability of CEREC-generated restorations was reported to be approximately 97 percent for five years and 90 percent for 10 years.

Clinical Implications. The low rate of restoration fracture and long-term clinical survivability document the effectiveness of the CEREC system as a dependable, esthetic restorative option for patients.

Key Words. Computer-aided design/computer-aided manufacturing; ceramics, clinical studies, margin wear.

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anterior crowns and veneers. The variety of ceramic restorations that can be fabricated in a dental laboratory also can be fabricated chairside with the CEREC 3 system.

Dentists have expressed a number of concerns about CEREC-generated restorations since their introduction. The CAM process elicited obvious concerns about the adaptation and marginal fit of the milled restoration. The adhesively cemented ceramic materials used in CEREC-generated restorations raised concerns about fracture resistance, durability and clinical longevity. Clinical research has been published that documents the effectiveness of the CEREC system. In this article, I review this literature and summarize the status of chairside CAD/CAM restorations.

POSTOPERATIVE SENSITIVITY

Early clinical studies on CEREC-generated restorations reported significant levels of postoperative sensitivity. In a study of 301 CEREC-generated inlays, Magnuson and colleagues[1] reported 9 percent immediate postoperative sensitivity. Although most of the cases involving sensitivity resolved within one month, three cases persisted for six months and required endodontic treatment to resolve them. Sjögren and colleagues[2] reported that 10 of 72 patients (13.8 percent) with 205 Vitablocs Mark I or II (Vita Zahnfabrik, Bad Säckingen, Germany) inlays had postoperative sensitivity. Fasbinder and colleagues[3] reported that 13 percent of 92 Vitablocs Mark II onlays were rated slightly sensitive at one week, and 4 percent were rated slightly sensitive at two weeks. All sensitivity was resolved by one month, and there was no postoperative sensitivity throughout the remainder of the three-year report. Otto[4] and Otto and De Nisco[5] reported 13 percent immediate sensitivity in 200 CEREC-generated inlays that they attributed to premature occlusal contact. Twelve of 17 cases resolved within a few days to three weeks. The remaining five cases resolved in seven months. Since the CEREC-generated restorations are placed in a single appointment, some postoperative sensitivity will be the result of occlusal interferences. The occlusal contacts may need to be equilibrated after the effects of the local anesthetic have dissipated and the patient has had the chance to live with the restoration.

As adhesive materials and luting techniques have improved, more recent clinical studies have reported less postoperative sensitivity. Molin and Karlsson[6] reported no sensitivity at any recall period for 20 Vitablocs Mark I inlays over five years. Heymann and colleagues[7] reported no postoperative sensitivity at any recall interval in their four-year clinical trial of CEREC-generated inlays. In a randomized clinical trial of 80 Vitablocs Mark II and Paradigm (3M ESPE, St. Paul, Minn.) inlays, Fasbinder and colleagues[8] reported one sensitive restoration at one week that was resolved by the second week. Sensitivity was not a factor over the three-year study period.

There are several possible reasons for the lack of significant postoperative sensitivity in chairside CAD/CAM restorations. Careful isolation is required to accomplish the optical imaging of the preparation, which ensures that the cavity can be isolated for adhesive cementation. Good isolation maximizes the predictability of the adhesive luting process. The ability to deliver the restoration in a single appointment also may minimize postoperative sensitivity, as it prevents the potential for tooth contamination during the temporization phase owing to fracture or loss of the temporary restoration or leakage and contamination under the temporary cement.

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RESTORATION FRACTURE

Mörmann and colleagues[9] reported on the first 94 Vitablocs Mark I inlay restorations placed with the CEREC 1 system between September 1985 and August 1987. After three years, they reported two fractured inlays. This initial low level of restoration fracture has been repeated in a large number of clinical studies on CEREC-generated restorations[1,2,4-23] (Table).

Berg and Derand[13] reported three fractures in 115 Vitablocs Mark II inlays over five years. In an early study of 121 Vitablocs Mark I and Dicor MGC (Dentsply International, York, Pa.) inlays, Isenberg and colleagues[10] reported seven fractured inlays over three years. All of the fractures occurred through the occlusal isthmus. Further evaluation of the fractured restorations indicated that the ceramic was less than 2.0 millimeters thick in the fracture area.

TABLE

CEREC* clinical studies.

STUDY (YEAR)	STUDY SETTING	EVALUATION PERIOD (YEARS)	EVALUATION CRITERIA	NO. OF PATIENTS	NO. OF RESTORATIONS
Mörmann and colleagues[9] (1991)	University	3	Modified U.S. Public Health Service (USPHS)	30	94
Magnuson and colleagues[1] (1991)	Private practice	2	California Dental Association (CDA)	103	301
Sjögren and colleagues[2] (1992)	Private practice	2	CDA	72	201
Isenberg and colleagues[10] (1992)	University	3	USPHS	NA†	121
Gladys and colleagues[11] (1995)	University	3	Clinical examination and scanning electron microscope (SEM)	20	24
Brauner and Bieniek[12] (1996)	University	6	Clinical examination	NA	453
Heymann and colleagues[7] (1996)	University	4	Modified USPHS	28	50
Otto[4] (1996)	Private practice	5	Clinical examination	108	200
Berg and Derand[13] (1997)	Private practice	5	Clinical examination and SEM	46	115
Cerutti and colleagues[14] (1998)	University	7	Modified USPHS	46	109
Sjögren and colleagues[15] (1998)	University	5	CDA	27	66
Molin and Karlsson[6] (2000)	University	5	CDA	20	20
Pallesen and van Dijken[16] (2000)	University	8	Modified USPHS	16	32
Reiss and Walther[17] (2000)	Private practice	12	Modified USPHS	299	1,011
Fasbinder and colleagues[18] (2001)	University	3	Modified USPHS	58	92
Otto and De Nisco[5] (2002)‡	Private practice	10	Modified USPHS	108	200
Posselt and Kerschbaum[19] (2003)	Private practice	3	Clinical examination and SEM	794	2,328
Bindl and Mörmann[20] (2004)	University	4	Modified USPHS	24	18
Sjögren and colleagues[21] (2004)‡	University	10	Modified USPHS	27	66
Bindl and colleagues[22] (2005)	University	4.5	Modified SPHS	136	208
Fasbinder and colleagues[8] (2005)	University	3	Modified USPHS	43	80
Reiss[23] (2006)‡	Private practice	18	Modified USPHS	299	1,011

* CEREC is manufactured by Sirona Dental Systems GmbH, Bensheim, Germany.
† NA: Not available.
‡ Second report on the same patient population as reported previously.

TABLE (CONTINUED)

CEREC* clinical studies.

TYPE OF RESTORATIONS	CEREC UNIT	MANUFACTURER'S NAME, CITY AND STATE	% OF FAILED RESTORATIONS	% OF FRACTURED RESTORATIONS
Inlays	1	Vitablocs Mark I (Vita Zahnfabrik, Bad Säckingen, Germany	2.1	2.1
Inlays and onlays	1	Vitablocs Mark I	1.9	0.7
Inlays	1	Vitablocs Mark I	3.4	2.0
Inlays and onlays	1	Vitablocs Mark I, Dicor MGC (Dentsply International, York, Pa.)	5.8	5.8
Inlays	1	Dicor MGC, Vitablocs Mark II	0	0
Inlays	1	Vitablocs Mark I	5.5	1.2
Inlays	1	Dicor MGC	0	0
Inlays and onlays	1	Vitablocs Mark I	1.0	0
Inlays	1	Vitablocs Mark I	2.6	2.6
Inlays	1	Vitablocs Mark I	0	0
Inlays	1	Vitablocs Mark II	6.1	4.5
Inlays	1	Vitablocs Mark II	5.0	5
Inlays	1	Vitablocs Mark II, Dicor MGC	9.4	9.4
Inlays and onlays	1	Vitablocs Mark II, Dicor MGC	8.0	4.0
Onlays	2	Vitablocs Mark II	3.3	2.2
Inlays and onlays	1	Vitablocs Mark I	8.0	4.3
Inlays and onlays	1 and 2	Vitablocs Mark II	1.5	0.3
Crowns	2	Vitablocs Mark II	5.5	5.5
Inlays	1	Vitablocs Mark II	10.6	6.1
Crowns	2	Vitablocs Mark II	16.3	3.4
Inlays	2	Vitablocs Mark II, Paradigm (3M ESPE, St. Paul, Minn.)	5.0	2.5
Inlays and onlays	1	Vitablocs Mark, Dicor MGC	8.5	3.3

Insufficient porcelain thickness is one of the major contributors to the fracture of porcelain restorations. Fasbinder and colleagues[8] reported that porcelain fracture was the primary failure mechanism for Vitablocs Mark II inlays, as two of the 40 inlays fractured over three years. They reported no fractured restorations for 40 Paradigm inlays.

Long-term studies have reported similar low fracture rates. Pallesen and van Dijken[16] reported three fractured restorations in a randomized clinical trial of 32 Vitablocs Mark I and Dicor MCG inlays over eight years. One inlay fractured at three years, and the other two had marginal ridge fractures at five years. No tooth fractures were reported during the recall period. Otto and De Nisco[5] reported an 8 percent failure rate for 200 Vitablocs Mark I inlays after 10 years of clinical service. Of the failures, eight were caused by ceramic fractures and three were caused by tooth fracture.

Posselt and Kerschbaum[19] reported 35 failures over nine years in 2,328 inlays and onlays in 794 patients that were generated with CEREC 1 and CEREC 2 units. The majority of failures were caused by two inlay fractures (5.7 percent), six tooth fractures (17.1 percent), eight tooth extractions (22.9 percent) and eight (22.9 percent) restorations placed for occlusal reconstruction.

The consistent reports of low failure and restoration fracture rates document the clinical durability of the

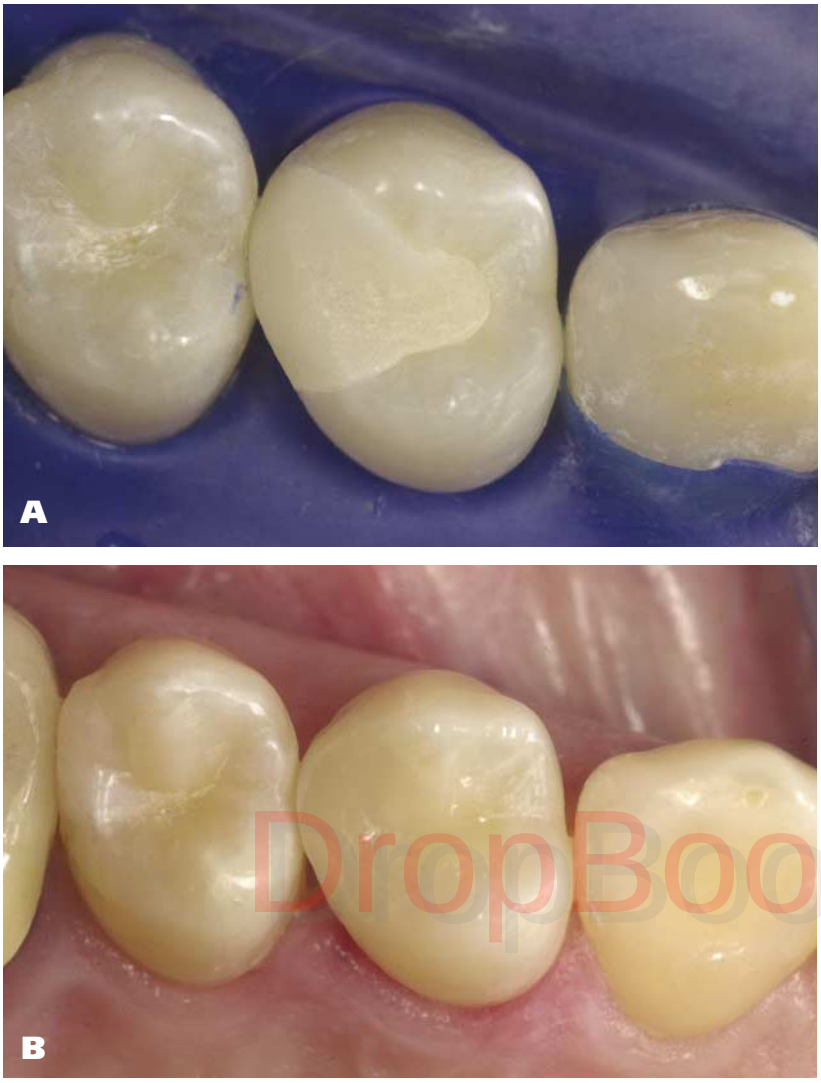

Figure 1. A. Try-in of ProCAD (Ivoclar Vivadent, Schaan, Lichtenstein) inlay. **B.** Cemented and polished inlay.

CEREC-generated restorations. Similar to other ceramic restorations, ceramic fracture and tooth fracture account for the primary failure mechanisms.[24]

COLOR MATCH

A custom stain and glaze technique can be used to modify the color of a porcelain restoration to ensure an esthetic match to a natural tooth. Herrguth and colleagues[25] compared the esthetic results of Cerogold crowns (Degussa Dental GmbH, Hanau, Germany) with CEREC-generated Vitablocs Mark II crowns that were stained and glazed. Each patient (n = 14) required an anterior crown and had two crowns fabricated, one from each material. Three independent examiners evaluated the crowns. Regardless of the type of crown, the crowns were esthetically acceptable to all patients and there was no significant difference in the esthetic results between the two crowns.

Most of the published clinical studies on CEREC-generated restorations have involved restorations milled from monochromatic blocks that are polished at cementation, rather than stained and glazed. The final color of the restoration is a function of the mill block shade, the resin-based composite luting agent shade and the underlying tooth shade (Figure 1).

Cerutti and colleagues[14] evaluated 109 inlays in 46 patients over seven years. They reported an initially good shade match of 88 percent Alfa that decreased to 62.4 percent Alfa and 33 percent Bravo after seven years. Molin and Karlsson[6] published a randomized clinical trial comparing three ceramic inlay systems—IPS Empress (Ivoclar Vivadent, Schaan, Lichtenstein), Mirage (Myron International, Kansas City, Kan.) and Vitablocs Mark II—with a cast gold inlay. Each of the 20 patients had the four inlays placed and were recalled over five years. The degree of color mismatch increased over the length of the study for all the ceramic systems. Empress changed from 15 percent color mismatch at baseline to 30 percent at five years, Vitablocs Mark I changed from 15 percent color mismatch at baseline to 40 percent at five years, and Mirage changed from 25 percent color mismatch at baseline to 50 percent at five years. Sjögren and colleagues[2,15,21] published three successive reports on 66 Vitablocs Mark II inlays from 1995 to 2004. Color mismatch increased from 16 percent at the five-year recall to 38 percent at the 10-year recall.

Fasbinder and colleagues[18] reported a similar decrease in color match over three years for Vitablocs Mark II onlays. The onlays had a good color match at baseline (84 percent Alfa), which decreased by the one-year recall (63 percent Alfa) and remained relatively unchanged at the three-

year recall (54 percent). A review of the color photographs taken at each recall examination indicated that the decrease in color match was due to a color shift in the tooth rather than a change in the color of the restoration. In a separate study, Fasbinder and colleagues[8] reported a similar decrease in color match for Vitablocs Mark II inlays. However, Paradigm inlays presented a significantly better color match after three years (91 percent Alfa rating). None of the patients reported displeasure with the color of any of the inlays at any recall period.

CEREC-generated restorations can provide clinically acceptable esthetic restorations when polished and optimum natural tooth color matching when stained and glazed. There tends to be an increase in color mismatch over time that has been attributed to a change in natural tooth color and translucency, rather than a change in the color of the restoration.

MARGIN ADAPTATION

Isenberg and colleagues[10] conducted a clinical study to evaluate the margin wear of Vitablocs Mark I and Dicor MGC inlays cemented with a microfill or hybrid resin-based composite luting agent. They reported a linear wear rate during the first year of clinical service. The wear rate then decreased by approximately 50 percent. The vertical loss of cement at the margin was less than 50 percent of the margin width. They reported no evidence of secondary caries or microleakage at the margins.

Heymann and colleagues[7] reported an increase in the wear of the luting agent at the occlusal margin of inlays over the first three years of clinical service, then a decrease in the amount of luting agent wear between three and four years. They did not identify inlay or enamel margin chipping as the luting agent began to wear. There was no margin staining or margin chipping associated with the cement wear.

Gladys and colleagues[11] reported no significant difference in margin adaptation between Vitablocs Mark I and Dicor MGC porcelain inlays and P-50 resin-based composite inlays after three years; however, they noted margin detection for all materials as early as six months. Submargination involved approximately 50 percent of the total margin length for all three inlay systems. Gladys and colleagues[11] also reported no recurrent caries and no marginal discoloration. In a study of 200 inlays, Otto and De Nisco[5] reported that the occurrence of underfilled margins increased from 12 percent at baseline to 74 percent at 10 years, but they attributed no clinical failure to the margin wear.

Fasbinder and colleagues[8] reported that margins were detectable clinically for Vitablocs Mark II and Paradigm inlays as early as six months. At the one-year recall, there was a significant difference in the margin adaptation, with the resin-based composite inlays having a greater percentage of nondetectable margins (91.4 percent) compared with those of the porcelain inlays (75.7 percent). By the three-year recall, there was no significant difference in margin detection between the composite and porcelain inlays, as both materials had 60 to 65 percent nondetectable margins.

Other studies have measured the resulting marginal gap due to luting agent wear over time. Berg and Derand[13] measured the margin gaps in CEREC 1–generated inlays. They reported distinct margin ditching present in all restorations after five years. The mean horizontal gap was 373 ± 147 standard deviation (SD) micrometers, and the mean vertical depth was 111 ± 67 µm. There was no significant difference between molars and premolars. There was no correlation between the material in the antagonist tooth and margin ditching.

Posselt and Kerschbaum[19] reported on 2,328 inlays and onlays placed in 794 patients that were fabricated with CEREC 1 and CEREC 2 units in one private practice. They selected 44 restorations at random to evaluate the margin gap. They reported an average margin gap of 236.1 ± 96.8 µm. Almost one-half (47.7 percent) of the measured margins exhibited an underfilled margin.

Bindl and Mörmann[26] compared the margin adaptation of Vitablocs Mark II crowns fabricated with CEREC 1 and CEREC 2 units. They reported a significantly improved margin adaptation for CEREC 2–generated crowns (207 ± 63 µm) compared with CEREC 1–generated crowns (308 ± 95 µm). They evaluated the margin adaptation with a scanning electron microscope at ×200 magnification and reported that 97 percent of the evaluated margins were continuous with slight submargination. The authors indicated that the margin gaps were greater than those previously reported for the CEREC system. Mörmann and Schug[27] compared the precision of fit between the CEREC 1 and CEREC 2 systems.

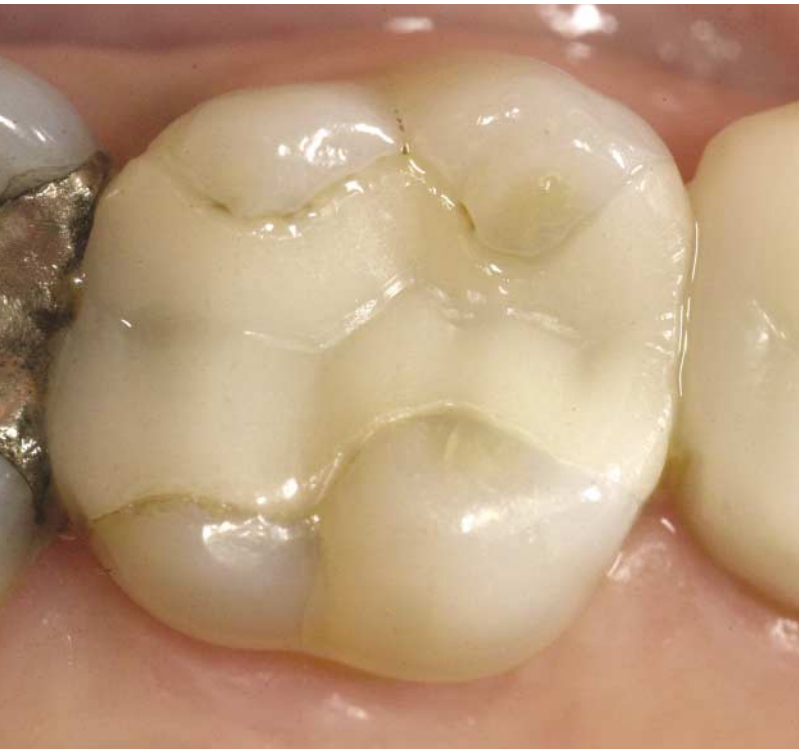

Figure 2. Margin wear and staining evident at the five-year recall of a Vitablocs Mark II (Vita Zahnfabrik, Bad Säckingen, Germany) inlay.

The mean margin interface was 84 ± 38 µm for CEREC 1–generated inlays and 56 ± 27 µm for CEREC 2–generated inlays. In a study on how the degree of taper in crown preparations affects the margin fit, Nakamura and colleagues[28] reported a margin gap of 53 to 67 µm for CEREC 3–generated crowns. In a study comparing the margin fit of CEREC 3–generated and laboratory-fabricated onlays, Denissen and colleagues[29] reported a margin gap of 85 µm for CEREC 3–generated onlays, which was not significantly different from that of the laboratory-fabricated onlays. Although the laboratory studies cited reported margin gaps well below 100 µm, the cited clinical studies reported larger margin gaps, as the luting agent wears from the margin.

It is expected that well-fitting margins will maximize the longevity of a restoration. Resin-based composite cement wear at the margin leading to ditching has been reported in almost all clinical evaluations of CEREC–generated inlays (Figure 2). Despite the detected margin wear, little margin discoloration or secondary caries was reported. This would indicate that the margin wear is a surface phenomenon and is not accompanied by a breakdown in the adhesive bond to the tooth. The ditching tends to be localized to the occlusal surfaces of the restoration as the proximal surfaces reveal minimal change at the margin. Microfill resin-based composite cements seem to show a superior wear resistance compared with hybrid resin-based composite cements.

CLINICAL LONGEVITY

Martin and Jedynakiewicz[30] reported a systematic review of clinical studies from 1986 to 1997 in an attempt to establish the survival rate of CEREC-generated restorations and identify factors that may cause them to fail. It was not a summary of published articles; rather, the authors extracted and analyzed the data common to the reviewed studies. They reported a failure rate of 2.6 percent and a mean survival rate of 97.4 percent for 2,862 CEREC-generated inlays in 15 clinical studies over a four-year period. Ceramic fracture was the overwhelming primary reason for failure, followed by supporting tooth fracture. Ceramic fracture was thought to be a result of occlusal stress or insufficient ceramic thickness.

Hickel and Manhart[24] reviewed clinical studies in the dental literature during the 1990s to determine annual failure rates of posterior restorations in stress-bearing areas. They reported annual failure rates of zero to 7 percent for amalgam restorations, zero to 9 percent for direct composite restorations, 1.4 to 14.4 percent for glass ionomer restorations, zero to 11.8 percent for composite inlays, zero to 7.5 percent for ceramic inlays, zero to 5.9 percent for cast gold inlays and zero to 4.4 percent for CAD/CAM ceramic restorations. Recurrent caries was the primary reason for the failure of the direct restorations (amalgam, composite and glass ionomer). Bulk fracture of the restoration and tooth fracture were the most frequent causes of failure for the indirect restorations (Figure 3).

Statistics dealing with restoration survivability indicate how long a restoration is maintained in function without modification, such as repair, replacement or extraction of the tooth. They do not assess the maintained restoration qualitatively. Brauner and Bieniek[12] reported a Kaplan-Meier method survival probability of 88.0 percent after 67 months for 238 Vitablocs Mark I inlays placed in a private practice. Otto and De Nisco[5] reported a Kaplan-Meier method survival probability of 90.4 percent after 10 years for 200 Vitablocs Mark I restorations placed in 108 patients in a Swiss private practice. Posselt and

Kerschbaum[19] reported on 2,328 inlays and onlays placed in 794 patients fabricated with CEREC 1 and CEREC 2 units in one private practice. The average observation period was 2.9 ± 2.2 years, with the longest recall time being nine years. The Kaplan-Meier method survival probability was 97.4 percent at five years, and it was 95.5 percent at nine years. There was no significant difference in survivability between inlays in premolars and molars or between maxillary and mandibular restorations. There was also no significant difference in survivability depending on the number of tooth surfaces involved in the restoration.

From 1995 to 2004 Sjögren and colleagues published three successive reports on 66 Vitablocs Mark II inlays.[2,15,21] The Kaplan-Meier method survival probability was 89.0 percent after 10 years. From 1991 to 2006, Reiss and Walther[17,23,31] published a series of articles on 1,011 CEREC-generated restorations placed between June 1987 and September 1990 in 299 patients in one private practice that they monitored for up to 18 years. After five years, the Kaplan-Meier method survival probability was 95.0 percent, and, after seven years, it dropped to 91.6 percent. The Kaplan-Meier method survival probability was 90.0 percent at 10 years, and it declined to 84.9 percent at 16.7 years. They reported more favorable prognosis for inlays in premolars (90 percent) than in molars (80 percent). There was no significant difference between restorations in the maxillary arch compared with restorations in the mandibular arch. There also was no significant difference in survivability based on the number of tooth surfaces restored.

CROWNS

Bindl and Mörmann[20] compared Vitablocs Mark II crowns with Vita In-Ceram Spinell (Vita Zahnfabrik) crowns that had been fabricated with a CEREC 2 unit. There was no significant difference between any of the U.S. Public Health Service ratings, and one crown of each type was fractured during the study. The Kaplan-Meier method survival probability was reported to be 91.7 percent for In-Ceram Spinell crowns and 94.4 percent for Vitablocs Mark II crowns after 44.7 ± 10.3 months.

Bindl and colleagues[22] also compared Vitablocs Mark II crowns based on the tooth type and type of preparation design. They described a classic crown preparation as having at least a 3.0 mm preparation wall height, 6- to 8-degree taper to the converging walls and a 1.0- to 1.2-mm shoulder. A reduced crown preparation had less than a 3.0-mm preparation wall height. An endodontic crown preparation did not have a remaining clinical crown on the tooth and used

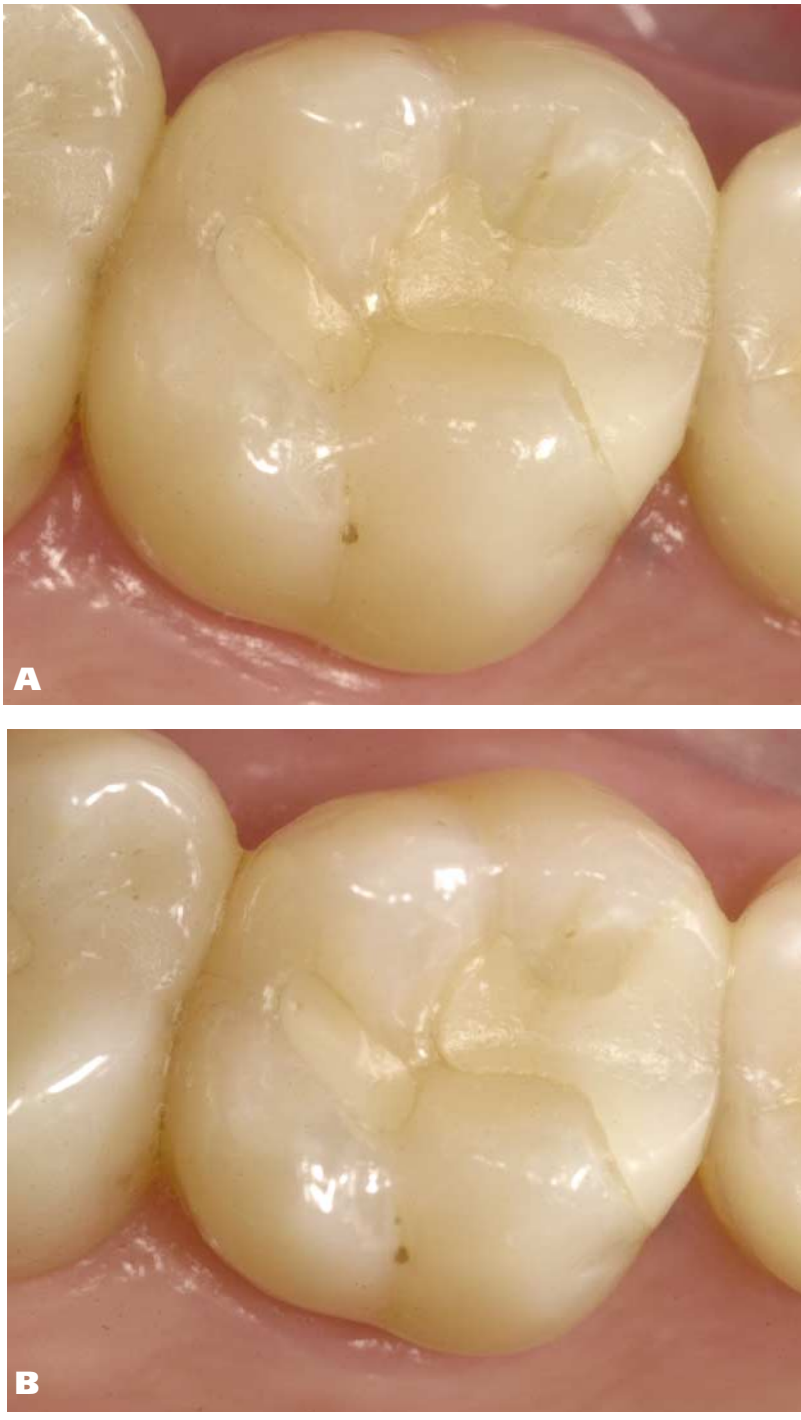

Figure 3. A. Nine-year recall of a Vitablocs Mark II (Vita Zahnfabrik, Bad Säckingen, Germany) inlay. **B.** Twelve-year recall of a Vitablocs Mark II inlay.

the pulp chamber for retention. For premolars, they reported a Kaplan-Meier method survival probability of 97.0 percent for classic crowns, 92.9 percent for reduced crowns and 68.8 percent for endodontic crowns. For molars, they reported a Kaplan-Meier method survival probability of 94.6 percent for classic crowns, 92.1 percent for reduced crowns and 87.1 percent for endodontic crowns. There was a significant difference in the survival probability between the premolar classic crowns and premolar endodontic crowns. They attributed the success of reduced crown preparations compared with classic crown preparations to the adhesive luting technique used for the Vitablocs Mark II material. They concluded that classic and reduced crowns were fine for premolars and molars, but endodontic crowns were acceptable only for molars.

CONCLUSIONS

A number of clinical studies have been published about CEREC-generated restorations, with some consistent findings. Although postoperative sensitivity has been reported in the initial postcementation period, it mainly is due to occlusal problems and resolves within the first several weeks to months. Long-term postoperative sensitivity was not a significant occurrence.

The consistent reports of low failure rates and restoration fractures document the clinical durability of CEREC-generated restorations. Similar to other ceramic restorations, ceramic fracture and tooth fracture are the two primary modes of failure for CEREC-generated restorations.

Clinically acceptable color matching of natural tooth color is possible by polishing the monochromatic blocks. Generally rated as good initial match, the degree of color mismatch tends to increase over time owing to the shift in color and translucency of the tooth, not of the restoration. To ensure optimum shade match, especially for anterior restorations, a more predictable result occurs with custom stain and glazing of the milled restoration.

Margin adaptation initially is good for CEREC-generated restorations, with an increase in margin discontinuity owing to wear of the resin-based composite luting agent. The degree of margin wear has been well-documented; however, little margin discoloration or secondary caries has been reported. This would indicate that the margin wear is a surface phenomenon and is not accompanied by a breakdown in the adhesive bond to the tooth, leading to failure of the restoration.

The survival probability of CEREC-generated restorations has been reported to be approximately 97 percent for five years and 90 percent for 10 years. The low rate of restoration fracture and long-term clinical survivability document the effectiveness of the CEREC system as a dependable, esthetic restorative option for patients. ■

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